Prepared for:

ALBERTA ENVIRONMENT

EARTH SCIENCES DIVISION - SOILS BRANCH

HYDROGEOLOGY OF THE YOUNGSTOWN SITE

SUMMARY REPORT

A Site Evaluation for the

Proposed

SPECIAL WASTE MANAGEMENT FACILITY

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SECTION ONE

INTRODUCTION

1.1 Introduction

A hydrogeologic investigation has been conducted on a quarter section legally described as NW 27-28-9-W4, and referred to herein as the Youngstown Site, to evaluate the feasibility of locating a special waste management facility in this area. The general area within which the site is located was identified through a constraint mapping process as exhibiting few or no hydrogeologic constraints to development. The quarter section was selected from the constraint-free area by the Special Areas Board (Special Area 3). Following selection, a test drilling program was implemented to collect detailed hydrogeologic information required to evaluate site suitability. This report represents a summary of the final report prepared at the conclusion of testing; the final report text contains a greater level of detail, and also contains hydrogeologic maps and cross sections at the 1:2000 scale. Hydrogeologic details are appended in the final report.

1.2 Location and Access

The Youngstown Site is located in southeastern Alberta approximately 10 km south of Youngstown (Figure 1.1). The quarter lies adjacent to Secondary Road 884, which joins Highway 9 near Youngstown. Travel time from Calgary (270 kms) is approximately 3 hours via Highway 9.

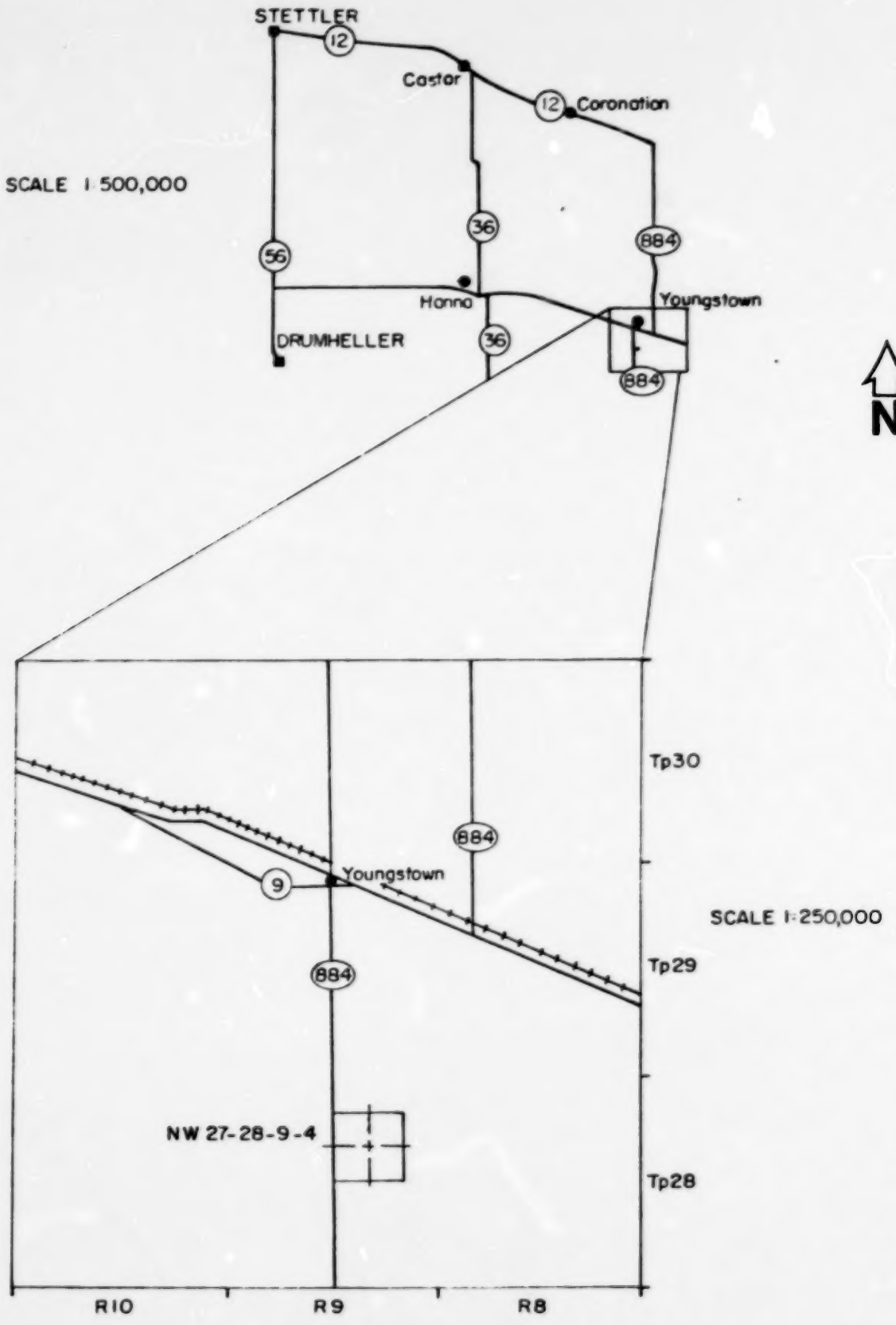


Figure 1.1 Location and Access Plan

SECTION TWO

LAND SURFACE DESCRIPTION AND USE

2.1 Topography and Drainage

The topography of the Youngstown Site is gently undulating with a total relief of 10.3 metres ranging from elevations of 793.6 to 803.9 metres geodetic. A topographic high occupies the central portion of the quarter, but the general regional slope is southeast. Depressional areas are located in the northwest corner, and sporadically distributed along the western boundary.

There are no permanent water courses on the quarter although two subparallel channels trend northwest-southeast across the northeast portion of the site. These have remained dry over a one-year observation period, and the lack of fluvial deposits suggest a glacial meltwater origin. Seasonal precipitation and snowmelt collects in several depressional areas along the western and eastern boundaries of the quarter. One of the dry channels has been dammed, and collects seasonal runoff for stock-watering.

2.2 Land Use

The Youngstown Site is crown-owned and leased to an area farmer; sparse prairie grass covers the entire quarter and is suitable for seasonal pasture only. The land surface is pock-marked with numerous blow-out depressions and ridged by soil drifting and plow furrows, indicating the native prairie was broken and farmed in the past.

SECTION THREE

GEOLOGY

3.1 Introduction

The geology of the Youngstown Site was investigated by drilling 25 test holes to 18 metres below surface on a 200 metre grid. The upper 18 metres was examined in greatest detail as the geology and groundwater characteristics of this interval is of greatest importance in siting a special waste management facility. Two additional test holes were drilled to 90 and 96 metres below surface in order to determine the general hydrogeologic characteristics of materials at greater depths. The locations of all test holes are indicated in Figure 3.1.

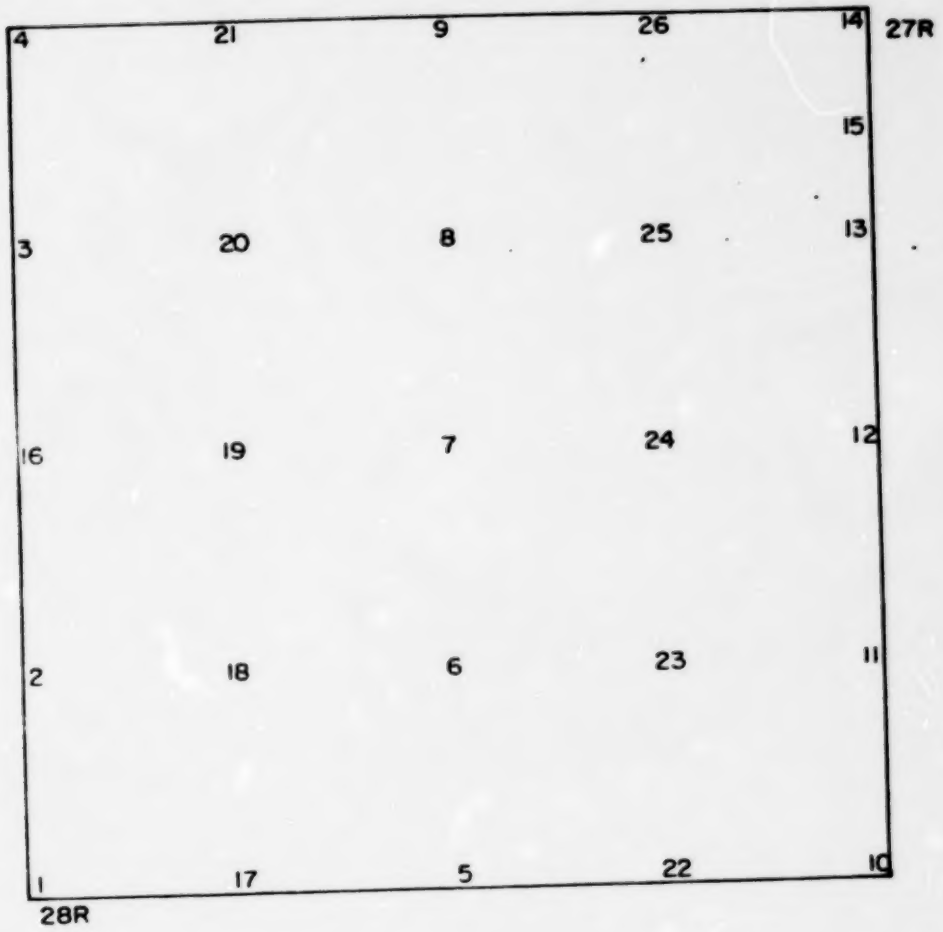
3.2 Surficial Geology

Surficial deposits mantling the Youngstown Site consist of clay loam-textured glacial till ranging from 1.8 to 6.0 metres thick. The till is overlain by a thin veneer of loose, weathered aeolian and colluvial debris. This material likely represents weathered till displaced by soil-drifting.

Glacial till is variably coloured brown to dark grey brown and is weathered throughout its thickness. The till near-surface is dry and friable, and grades downward to moist and stiff at the bedrock contact.

In view of the thin till cover, the surface topography is controlled to a large extent by the bedrock topography.

Figure 3.1 Test Hole Location Plan - Youngstown Site



NOTES

1 Rotary holes denoted by R

2 Drill hole grid is 200m (approximate)

3 Map area denotes NW 27-28-9-W4

3.3 Bedrock Geology

Bedrock deposits beneath the till cover consist of shale, siltstone and sandstone to a depth of 96 metres below surface. Based on mineralogical and fossil evidence, the entire sequence is part of the Bearpaw Formation.

The stratigraphic sequence to a depth of 30 metres consists of silty clay loam, clay, and clay loam-textured shale. The dark grey to greenish grey shale contains glauconitic sand grains and fossil fragments at specific intervals in the subsurface. The sequence is largely unconsolidated except for a few well-indurated siliceous and concretionary horizons. Free water was encountered at several sporadic locations within the upper 30 metres, indicative of water-bearing fractures. Except for these, the shale is dry or only slightly moist.

The sediments at depths greater than 30 metres consist of interbedded argillaceous sandstone, shale and siltstone. As glauconite and fossil fragments indicative of marine sediments were observed to the 96 metre base of investigation, it is considered that the entire bedrock sequence investigated is part of the Bearpaw Formation.

The textural range of the lithologic sequence is indicated in Table 3.1 and Figures 3.2 to 3.4. Sandstones in the sequence contain up to a maximum of 52% sand, indicating a high silt and clay matrix content (Figure 3.2).

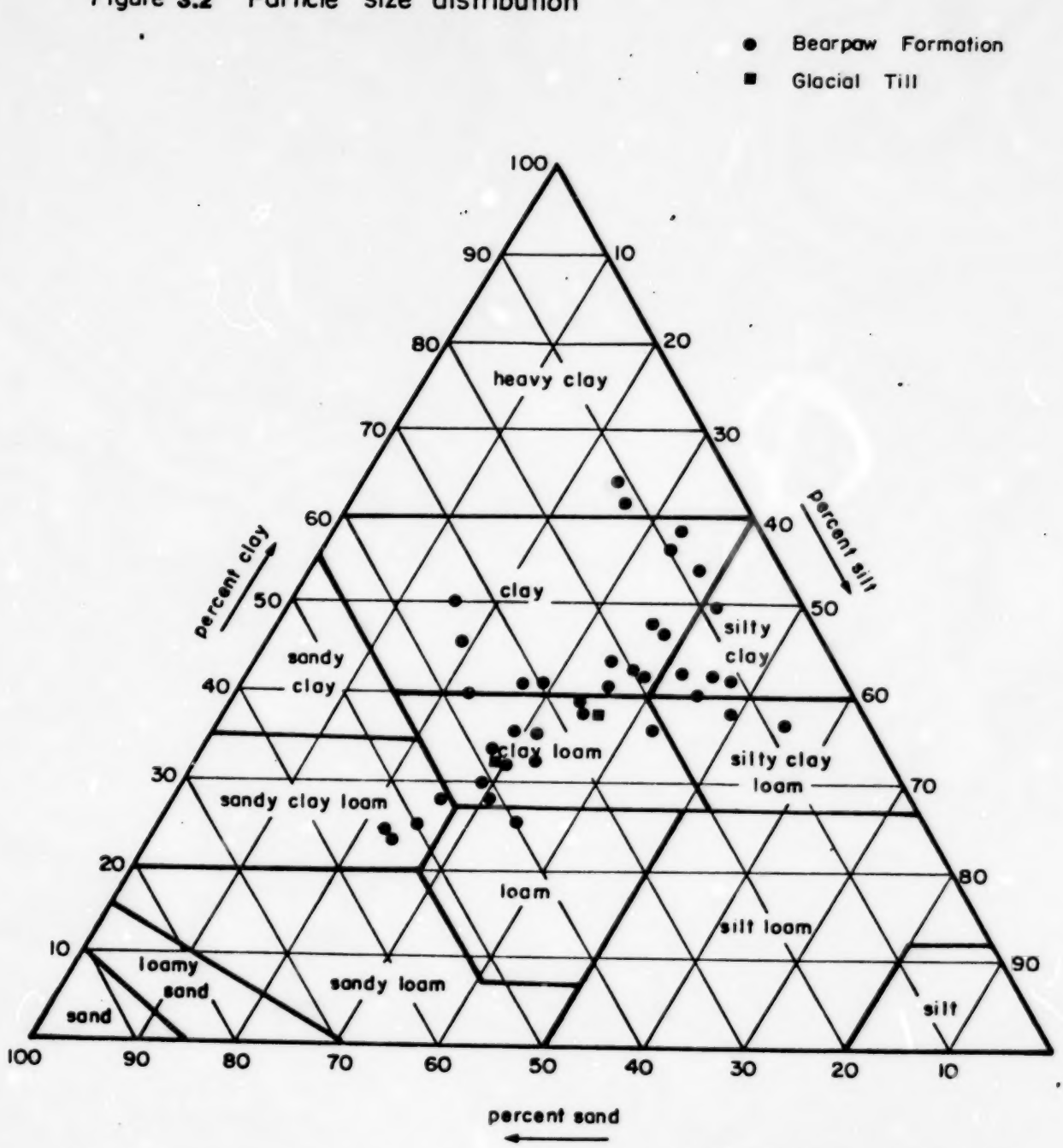
Table 3.1: Particle Size Analyses

Sample No.	Depth(m)	Material	Texture
M 7 - 1	1	Till	Floculated
2	2	Till	CL
3	3	Till	CL
4	4.5	Shale-weathered	SiCL
5	6	Shale-unweathered	SiCL
6	7.5	Shale	SiC
7	9	Shale	SiC
8	10.5	Shale	ND
9	12	Shale	C
10	13.5	Shale	C
11	15	Shale	C
12	16.5	Sandy Shale	C
13	18	Sandy Shale	C
14	19.5	Sandy Shale	C
15	21	Sandy Shale	CL
16	22.5	Sandy Shale	C
17	24	Sandy Shale	C
18	25.5	Sandy Shale	C
19	27	Sandy Shale	CL
20	28.5	Sandy Shale	CL
21	30	Shale	CL
M28 - 6	34	Sandy Shale	CL
7	37	Clayey Sandstone	CL
8	40	Shale	SiC
9	43	Shale	C
10	46	Shale	SiC
11	50	Sandy Shale	C
12	53	Sandy Shale	CL
13	56	Clayey Sandstone	SCL
14	60	Clayey Sandstone	CL
15	63	Shale	C
16	66	Shale	HC
17	70	Clayey Siltstone	HC
18	72	Clayey Siltstone	C
19	75	Clayey Siltstone	SCL
20	77	Clayey Siltstone	CL
21	80	Sandstone	SCL
22	83	Sandy Shale	SCL
23	87	Silty Shale	SiC
24	90	Sandy Shale	C
25	93	Clayey Siltstone	L
26	96	Sandy Shale	CL

Legend:

CL - Clay Loam
SiCL - Silty Clay Loam
SiC - Silty Clay
C - Clay
SCL - Sandy Clay Loam
HC - Heavy Clay
L - Loam
ND - Not Determined

Figure 3.2 Particle size distribution



N = 38 (bedrock samples)

Field	% samples in field
SCL	10.5
L	2.6
CL	26.3
SiCL	5.3
Sic	13.2
C	36.8
HC	5.3

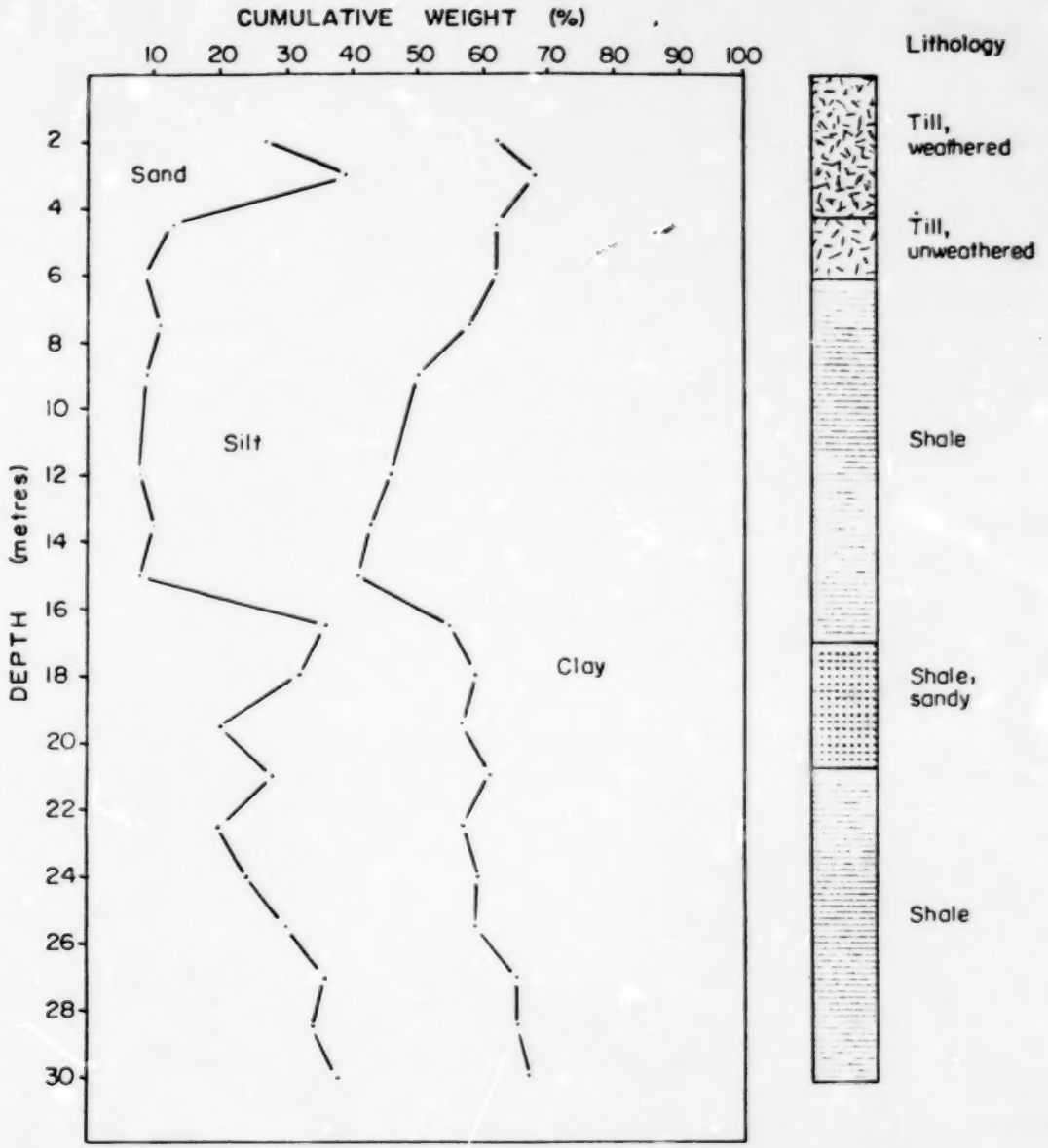
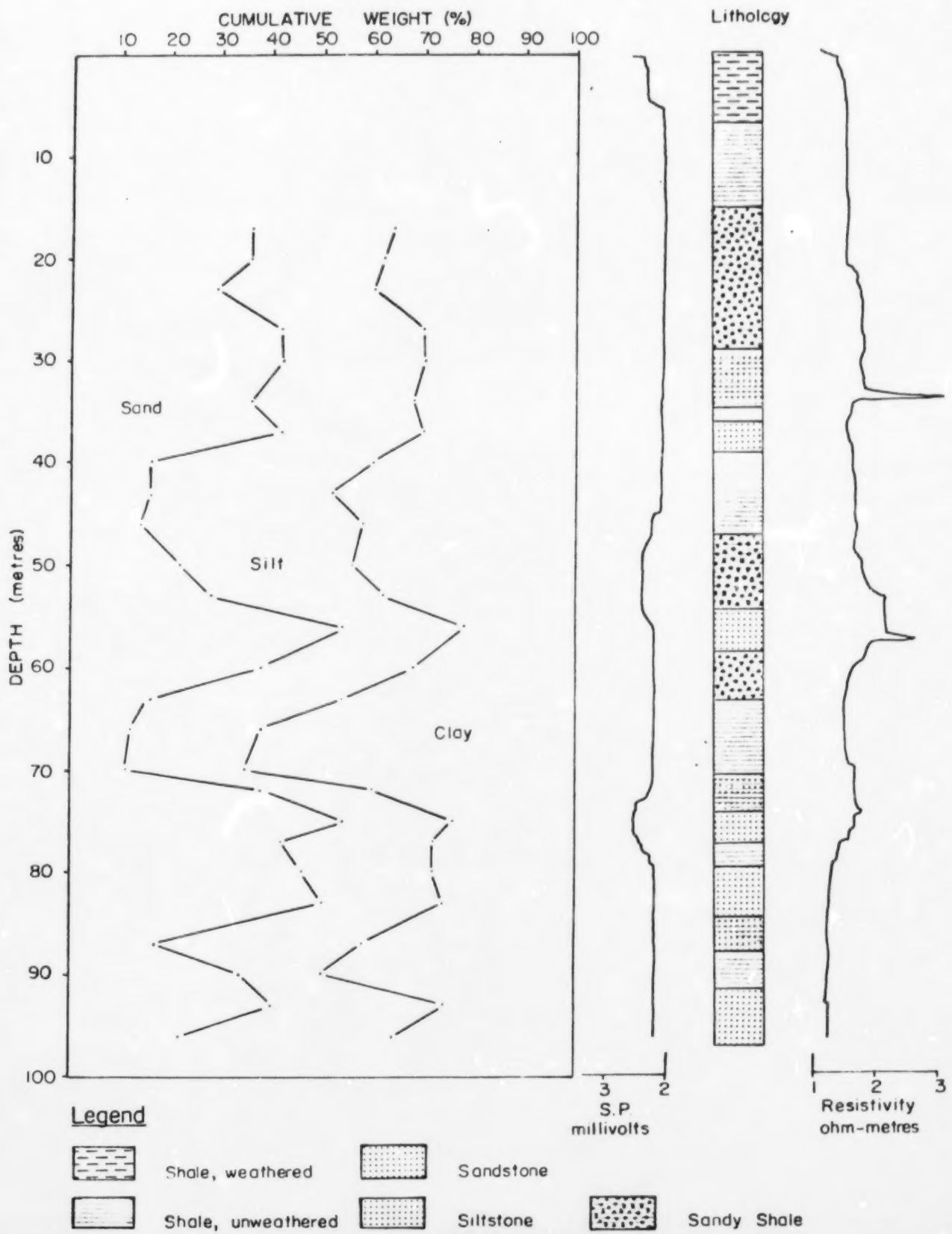


Figure 3.3 TEXTURAL VARIATION WITH DEPTH

TEST HOLE No. 7

Figure 3.4 TEXTURAL VARIATION WITH DEPTH

TEST HOLE No 28



SECTION FOUR

GROUNDWATER

4.1 Introduction

Groundwater information was collected from a piezometer network consisting of 25 nests placed at 200 metre intervals over the Youngstown Site. Each nest contains at least 3 piezometers completed at approximate depths of 6, 12 and 18 metres below surface. Information compiled from monitoring results included watertable depth and configuration, groundwater flow direction and hydraulic conductivity data. Groundwater velocities were calculated using hydraulic conductivity and watertable configuration data.

The aquifer potential of the lithologic sequence was estimated by air-lifting groundwater from the two deep boreholes.

4.2 Hydraulic Conductivity of Geologic Deposits

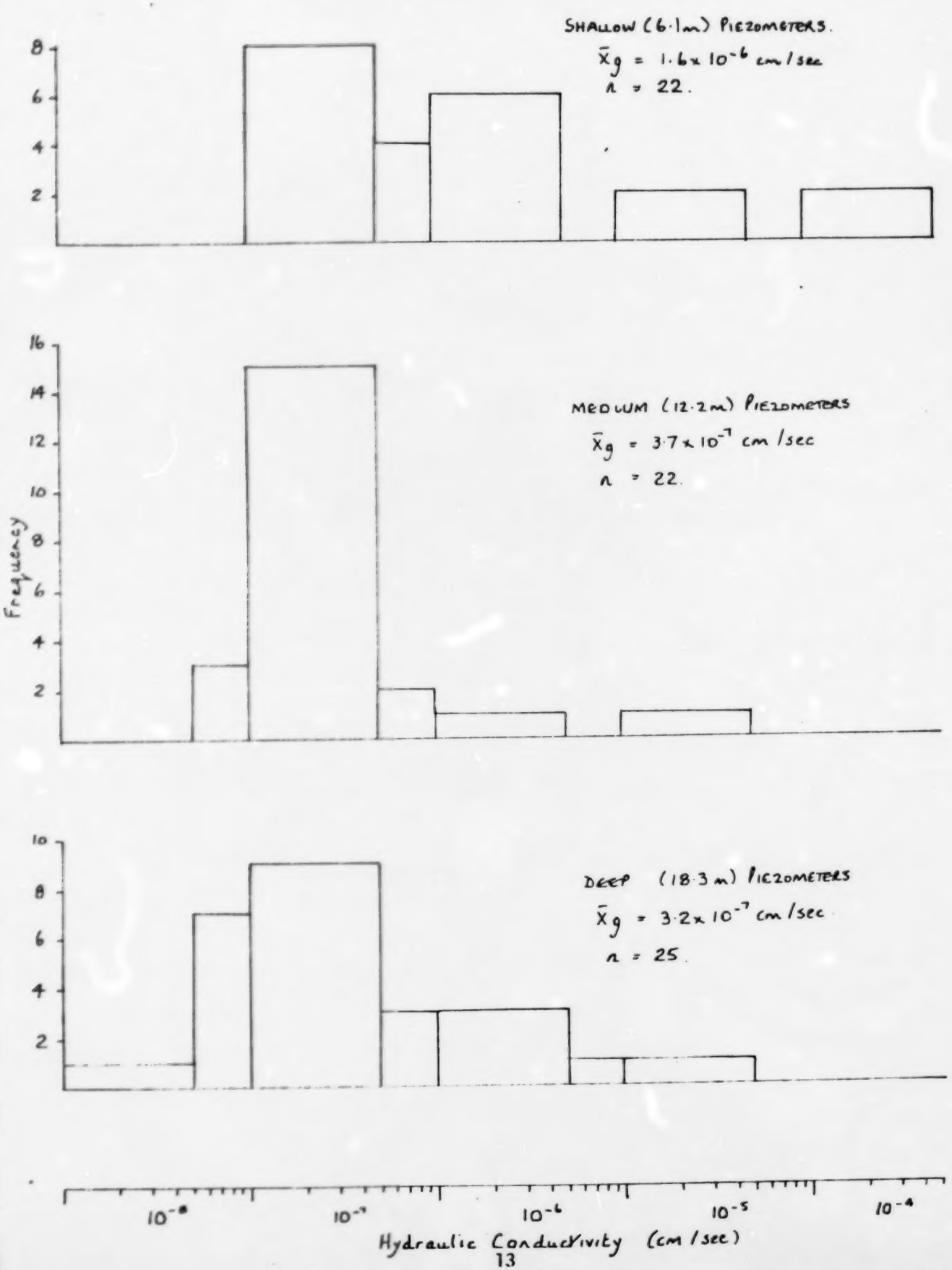
A total of 70 single well response tests were conducted at the Youngstown Site, 22 at each of the 6 and 12 metre depths and 25 at the 18 metre depth. A single test was completed on a piezometer installed to 30 metres. The resultant hydraulic conductivity values from each piezometer are listed in Table 4.1, and a graphic distribution of values is illustrated in Figure 4.1.

Hydraulic conductivity values are highest at the 6 metre depth where a number of piezometers are completed in weathered materials. Only 4 of the 22 values are greater than 10^{-6} cm/s, however, and the mean hydraulic conductivity value of 1.6×10^{-6} cm/s indicates that the

Table 4.1: Distribution of Hydraulic Conductivity (K) Values

Shallow Piezometer (6 m)		Medium Piezometer (12 m)		Deep Piezometer (18 m)	
Piez. No.	K (cm/s)	Piez. No.	K (cm/s)	Piez. No.	K (cm/s)
1S	1.3×10^{-6}	1C	4.8×10^{-7}	1N	2.9×10^{-8}
2S	2.0×10^{-5}	2C	4.8×10^{-7}	2N	8.4×10^{-8}
3S	3.7×10^{-7}	3C	4.6×10^{-7}	3N	7.1×10^{-8}
4S	2.2×10^{-4}	4C	3.2×10^{-7}	4N	8.6×10^{-6}
5W	2.3×10^{-6}	5C	2.5×10^{-7}	5E	5.5×10^{-8}
6W	Dry	6C	2.0×10^{-6}	6E	5.8×10^{-7}
7W	Dry	7C	Dry	7E	7.3×10^{-8}
8W	4.3×10^{-7}	8C	4.6×10^{-7}	8E	1.4×10^{-6}
9W	4.8×10^{-6}	9C	3.8×10^{-7}	9E	2.1×10^{-6}
10W	3.2×10^{-7}	10C	8.6×10^{-8}	10E	1.6×10^{-6}
11W	3.5×10^{-7}	11C	Dry	11E	2.1×10^{-7}
12W	2.8×10^{-6}	12C	1.2×10^{-7}	12E	3.5×10^{-7}
13W	3.2×10^{-7}	13C	3.1×10^{-5}	13E	9.8×10^{-7}
14W	1.9×10^{-5}	14C	8.9×10^{-8}	14E	7.6×10^{-8}
16S	9.1×10^{-7}	16C	1.0×10^{-7}	16N	7.0×10^{-8}
17W	2.7×10^{-6}	17C	1.2×10^{-7}	17E	2.4×10^{-7}
18W	4.6×10^{-7}	18C	1.9×10^{-7}	18E	3.7×10^{-7}
19W	2.7×10^{-7}	19C	5.3×10^{-7}	19E	3.4×10^{-7}
20W	7.3×10^{-7}	20C	1.4×10^{-7}	20E	4.1×10^{-7}
21W	7.6×10^{-7}	21C	4.4×10^{-7}	21E	2.0×10^{-7}
22W	1.0×10^{-6}	22C	3.7×10^{-6}	22E	6.4×10^{-7}
23W	1.3×10^{-7}	23C	Dry	23E	8.2×10^{-8}
24W	Insuff. Water	24C	8.6×10^{-7}	24E	4.2×10^{-5}
25W	5.1×10^{-7}	25C	2.9×10^{-7}	25E	1.1×10^{-7}
26W	1.3×10^{-4}	26C	5.7×10^{-8}	26E	1.2×10^{-7}

FIG. 4.1 GRAPHICAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY VALUES



materials at most locations tested are only poorly permeable. Hydraulic conductivity values are lower at the 12 and 18 m depths (means of 3.7×10^{-7} and 3.2×10^{-7} cm/s respectively); deposits with hydraulic conductivities of these magnitudes would normally be considered impermeable. A value of 4.2×10^{-5} cm/s in piezometer 24E (18 metre depth - Table 4.1) indicates the shale at this depth is fractured. The fractured shale was anticipated as free water was intercepted at this depth during piezometer installation. Other instances of open fractures were rarely encountered during the investigation.

4.3 Watertable Depth and Configuration

The watertable lies at depths ranging from 2.5 to 5.5 metres below ground surface and is contained by poorly permeable deposits of either till or the upper bedrock shale. The watertable is deepest beneath topographically higher areas, but the configuration generally conforms to surface topography.

A contour of the watertable surface indicates a general slope from west to east with local deviations in the vicinity of the meltwater channels. Ignoring local perturbations caused by topography, the hydraulic gradient is approximately 8.7×10^{-3} along a west to east flow line.

4.4 Groundwater Velocity

The velocity of groundwater flow as calculated using mean hydraulic conductivity and gradient values, is in the order of 4 cm/year. Velocity values may be higher or lower than the mean in the vicinity of each piezometer, but average values are considered sufficient to demonstrate the watertable is contained by poorly permeable geologic deposits.

4.5 Vertical Groundwater Flow

The groundwater velocity calculations are based on a horizontal component of groundwater flow near the watertable. A vertical component of groundwater flow is also present, and comparison of three piezometric levels in the subsurface indicates that slight recharge gradients are present beneath the Youngstown Site. The dominant path of groundwater flow is parallel to surface topography, however, as the hydraulic conductivity of stratified sediments is generally less in the vertical than in the horizontal direction.

4.6 Aquifer Potential

Test holes were drilled to 90 and 96 m depths at the NE (#27) and SW (#28) corners of the quarter to investigate the aquifer potential of Bearpaw sediments beneath the Youngstown Site. Groundwater yields from the entire lithologic column of both test holes were determined by compressed air-lift. The tests proved hole No. 27 dry and No. 28 produced approximately 2 L/min. The lack of groundwater plus the hydraulic conductivity data presented in a previous section confirms that widespread, water-producing fractures are likely absent at depth beneath the Youngstown Site and the shales are relatively impermeable to the movement of groundwater.

SECTION FIVE

SUMMARY AND CONCLUSIONS

The hydrogeologic setting of a quarter section legally described as NW 27-28-9-W4, and referred to herein as the "Youngstown Site", was investigated through drilling and piezometer installation. The purpose of the investigation was to evaluate potential suitability of the site for development of a waste management facility.

Surface materials consist of a thin veneer (less than 1 m thick) of aeolian and residual soils developed on glacial till. The till is a clay-loam textured blanket over a Cretaceous-age sedimentary bedrock surface. The till mantle ranges from 1.8 to 6.0 m thick and contains minor lenses and pockets of glaciofluvial sands and occasional gravels. A weathering zone extends through the till and into the underlying bedrock surface over most of the map area.

Bedrock deposits consist of silty shales to depths in the order of 30 m, and interbedded silty shales, sandy shales and argillaceous sandstones from 30 to 96 m. The sedimentary sequence is relatively soft, and contains minor bands of indurated sediments in the order of several centimetres thick. The presence of glauconitic sands interbedded in the lower part of the sequence, and marine invertebrate fossils in the upper part indicate a marine origin for the full thickness of sediments investigated. Since subcrop in this region is mapped as the marine Bearpaw Formation, it is considered that Bearpaw sediments extend to depths greater than 96 m at the Youngstown Site.

The hydraulic properties of geologic materials at three levels in the subsurface were determined by conducting response tests on piezometers. Piezometer nests were installed at 25 locations on the quarter, with three piezometers in each nest completed at 6, 12, and 18 m below surface.

The hydraulic conductivity of the stratigraphic sequence investigated decreases with depth. Mean hydraulic conductivities for the three levels are 1.6×10^{-6} cm/s (six m depth), 3.7×10^{-7} cm/s (12 m depth), and 3.2×10^{-7} cm/s (18 m depth). A single piezometer completed at the 30 m depth yielded a hydraulic conductivity in the order of 10^{-8} cm/s.

Conductivity values range over several orders of magnitude, from 10^{-4} to 10^{-7} cm/s in the upper level, and from 10^{-5} to 10^{-8} cm/s in the intermediate and lower levels. Observations during test drilling coupled with high hydraulic conductivity values in the 10^{-4} - 10^{-5} cm/s range indicate that open fractures are likely intersected by some of the piezometer tips (of 69 tests conducted, two yielded conductivity values in the order of 10^{-4} and four yielded values in the order of 10^{-5} cm/s). The data indicate that, while the incidence of fracturing appears to be low, an assumption as to the presence of fractures is necessary and the engineering design must compensate accordingly.

The configuration of the watertable, as indicated by static levels in the shallow (six m depth) piezometers indicates groundwater flow from west to east beneath the Youngstown Site. The general west to east flow direction is locally influenced by topographic features, since the watertable configuration approximates the topographic configuration. The horizontal velocity of groundwater flow near the watertable is an estimated 4 cm/yr assuming a mean hydraulic gradient, mean hydraulic conductivity at the six m depth, and assuming flow is governed primarily by intergranular rather than fracture porosity. The relatively steep mean gradient does not support the presence of an extensive fracture network at the six m depth.

Watertable depth beneath the Youngstown Site presently ranges from 2.5 to slightly in excess of 5.5 m below surface based on August, 1983 levels. The watertable is closest to the surface along the western and eastern portions of the quarter, and deepest beneath the topographically higher central portion. It should be appreciated that groundwater at and beneath the watertable is contained by poorly pervious sediments which greatly restrict the velocity at which groundwater can flow. Sediments of this nature are termed aquitards or aquicludes, and viable water supply wells generally cannot be developed in such materials.

Rotary drilling and geophysical logging was conducted to depths of 96 m in order to determine the position of potential aquifers. Although argillaceous sandstones were encountered at depth, none contained significant quantities of groundwater. Compressor tests were conducted on two open holes drilled to 90 and 96 m respectively. Negligible quantities of groundwater were recovered from one, and two L/min were recovered from the second test hole. It is concluded that, to the depths investigated, no significant aquifers are present beneath the Youngstown Site.

Given the geology and groundwater conditions identified, the Youngstown Site satisfies "favourable" criteria as outlined in Site Selection guidelines established by Alberta Environment for the location of waste management facilities. An exception is the watertable depth, which is excessively high over a portion of the site. Waste disposal trenches excavated to practical depths would likely encounter the watertable beneath topographically low areas. This is not a serious limitation where waste materials consist of inert, non-toxic solid residues, or liquids which have been chemically converted ("fixed") to an insoluble solid state. It is considered that criteria specifying watertable depth should be flexible, since there are no aquifers beneath the Youngstown Site which would be affected in any case.

SECTION SIX

RECOMMENDATIONS

The Youngstown Site is suitable to development of a waste management facility, but several factors require consideration at the detailed design stage. Foremost among these is the type, state, and volumes of material which will require burial. It is our understanding that only inert, innocuous and non-hazardous materials will be buried beneath the surface and, in this instance, the concern for groundwater contamination is non-existent; any portion of the site could be used for trenching/burial.

Should chemically reactive substances require burial, however, then these must be placed above the watertable in accordance with guidelines established by Alberta Environment. In this instance a smaller portion of the Youngstown Site is available for land disposal, depending upon the engineering design of the landfill.

One alternative, should there be a landfill requirement for both inert and chemically reactive waste, is to partially backfill deep trenches (excavated below the watertable) with inert materials. The more reactive waste materials could then be placed in upper portions of trenches which lie above the watertable. It should be recognized that placement of compacted materials below the watertable could interfere with existing groundwater flow patterns. Trench placement and alignment should be carefully considered to avoid groundwater damming effects.

A second alternative is to install drain pipes to lower the watertable to the desired elevation. Owing to topographic relief on the site, gravity drains are possible in some areas down to certain elevations. In view of the poorly conductive nature of subsurface geologic materials, however, this alternative requires detailed evaluation at the design stage.

Regardless of the method selected, all excavations for waste burial should be designed to eliminate potential fracture systems, particularly within the weathered zone. Scarification and recompaction of trench bases and sideslopes is suggested, but the most appropriate method will be at the discretion of the design engineer following geotechnical investigations.

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